HOURLY PRECIPITATION AT NASHVILLE, TENN.

By ROSCOE NUNN, Meteorologist.

[Weather Bureau, Nashville, Tenn.]

Requests from insurance companies for data to be used in connection with "rain insurance" prompted the writer to compile the information in this article. Questions could have been answered in a general way, though not satisfactorily, without going into these details, but the subject is probably of sufficient general interest to justify careful treatment. The Nashville records no doubt give a fair representation of a considerable district in this part of the country, and probably have some advantages over the data for more northern points for a study of this kind, as the hourly automatic records are more complete for the cold months, snowfall not being automatically registered.

Up to this time data for hourly values of precipitation have been available for only short periods, and even now very few stations have records of hourly values for more than the last 17 years. However, interesting studies of hourly amount and frequency of precipitation were published by Dr. O. L. Fassig, *The Climate of Baltimore*, in volume 2, "Maryland Weather Service," 1907, and by Prof. H. J. Cox and Mr. J. H. Armington, *The Weather and Climate of Chicago*, 1914. In both cases records of a 10-year period were used.

In order to determine whether there exist any marked diurnal periods in amount or frequency of precipitation at Nashville, the hourly values as recorded in Form No. 1014, Daily Local Record, were carefully examined. This station has a good automatic record of precipitation and the hourly amounts are entered on Form 1014, beginning with January, 1905. The records for the years 1905–1921, inclusive, are therefore used, giving a period of 17 years. As only about 2 per cent of the annual precipitation at Nashville is in the form of snow, the automatic record for the entire year could be used, it being deemed permissible to estimate the hourly amounts in cases of snowfall.

In computing the hourly frequency it was thought worth while to prepare data, first, for all occurrences, including traces, and, second, for occurrences of measurable amounts only. This brings out the fact that a large percentage of the records of precipitation are for traces. If we consider all hours having precipitation (including traces), we find that not much more than one-half of the hours have measurable amounts, 0.01 inch or more. In January, hours having 0.01 inch or more are 54 per cent of the total hours with precipitation, and the percentages for the other months are as follows: February, 49; March, 54; April, 58; June, 59; July, 56; August, 58; September, 58; October, 56; November, 56; December, 55. Graphs showing the frequency for all amounts, including traces, and for measurable amounts only, are interesting when compared in that they seem to show that records of traces are more frequently made around the regular morning and evening observation hours than during the busier office hours, or at night. For this and other reasons, the data for frequency of measurable amounts (0.01 inch or more) would seem to be more valuable than the data which include traces.

An explanation of the term "frequency" as used here should perhaps be given. It means simply the number of times precipitation was registered in each hour, expressed in percentage of the possible, and has little to do with the duration of precipitation or with separate occurrences—that is, the number of times precipitation began and ended. If, for example, rain began at 3:45 p. m. and ended at 4:10 p. m., the two hours would be counted as having precipitation, although all of it occurred within 25 minutes. Again, if rain began at 2:30 a. m. and continued until 10:30 p. m., there would be 20 hours with precipitation, although only one period.

The duration of precipitation—actual number of hours rain or snow was falling—has not been compiled for a period of sufficient length to give a satisfactory average, but a single year, 1920, is used to throw some light on this phase of the subject. The year 1920 had nearly the normal amount of precipitation for the year as a whole, and also nearly normal amounts for the four seasons, although several of the monthly amounts differed decidedly from the normal. January, April, and August were unusually wet, while February, March, and November were unusually dry, but the seasonal and annual amounts were nearly normal. Table 1 shows the actual number of hours, also the percentage of the total hours, that precipitation was occurring, for each month of the year 1920.

Year 1920	Duration of precipitation, hours.	Percentage of time precipitation was occurring.	Year 1920.	Duration of precipitation, hours.	Percentage of time precipitation was occurring.
January	132.2	17.8	August	46.1	6.2
February	120.7	17.3	September	35.6	4.9
March	85.8	11.5	October	15.3	2.1
April	86.2	12.0	November	66.1	9.2
May	54.7	7.4	December	94.2	12.7
June	44.5	6.2			
July	24.4	3.3	Annual	805.8	9.2

In the beginning traces of precipitation were considered: that is, precipitation was counted as going on no matter how light it might be. Drizzly days cause the duration figures to mount up, although there may not be much precipitation to show for it. Winter months, therefore, have much longer duration of precipitation than do the summer months, which more frequently receive their precipitation mostly in quick, heavy showers. The actual amount of precipitation normally received is only slightly greater in winter than in summer.

From the accompanying tables and charts (tables 1 and 2 and figs. 1–3), showing the hourly amounts in inches and the hourly frequency in percentage of the possible, it may be readily observed that there are no strong diurnal periodicities, either in amount or frequency of precipitation at Nashville. However, two fairly well-defined periods of maxima and two of minima may be discovered in the 24 hours. Considering first the hourly amounts and taking the year as a whole, there is a maximum period which begins to come on about 3 a. m. and culminates about 5 a. m. This is followed closely by a minimum period beginning about 6 a. m. and culminating about 9 a. m. Beginning about 10 a. m., there is an unsteady rise in the amount of precipitation, which continues for several hours and culminates about 4 p. m., and the hour ending at 4 p. m. shows the greatest precipitation of any hour of the day. After 4 p. m. the hourly amounts diminish rather steadily and reach a minimum about 10 p. m. During the midnight hours the precipitation fluctuates somewhat, but these hours belong to a minimum rather than a maximum period.

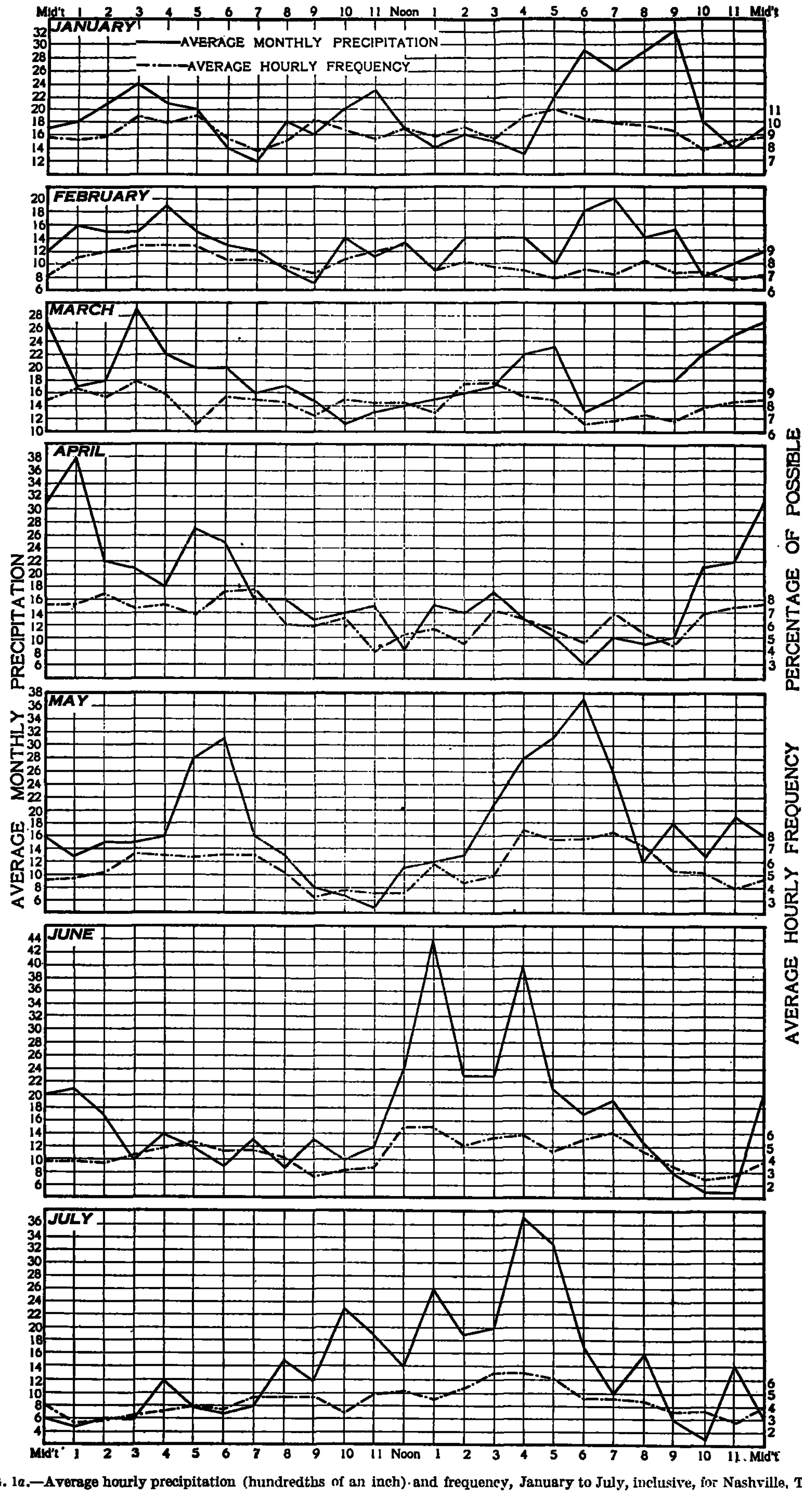

FIG. 1a.—Average hourly precipitation (hundredths of an inch) and frequency, January to July, inclusive, for Nashville, Tenn.

The range of hourly frequency follows in a general way the rise and fall of the hourly amounts, except that from about 12 noon to 3 p. m. the line of frequency is nearly straight, running at a comparatively low level.

The periods of maxima and minima shift somewhat and increase or diminish in intensity with the seasons. The distribution of precipitation through the 24 hours is decidedly more uniform during the winter than in the summer. Heavy afternoon showers characterize the records in summer.

We have just been considering the averages for the year as a whole. Most of the individual months have the characteristics of the year as a whole, but some differ so widely that mention should be made of them. For example, the frequency in February is relatively high from 10 a. m. to 12 noon and low in the afternoon; April frequency is greatest for the hour ending at 7 a. m., instead of some afternoon hour, and after 7 a. m. it diminishes irregularly until 11 a. m. and is low for several hours in the middle of the day; June shows high frequency from noon to 1 p. m.; November frequency shows a slow downward trend almost all the way from 5 a. m. to 8 p. m., then rises rather sharply to 11 p. m.

A long record, 50 years or more, would no doubt produce much smoother graphs, as a few very unusual occurrences affect a short record greatly, whereas their effect in a long record would be distributed and decidedly modified.

After all allowances are made, however, for what may be called accidental occurrences, the existence of the double maxima and double minima in the 24 hours seems to be appreciable. They are not entirely obliterated by storm movements. There seems to be a diurnal march of precipitation somewhat similar to the diurnal march of pressure. The sun shining upon the rotating earth is the ultimate cause of both. Noting the fact that the amount and frequency of precipitation are relatively high about 5 a. m., we remember that this is normally the time of greatest chilling of the air and of greatest percentage of humidity, and, other things being equal, condensation and precipitation should occur more frequently about this time than during the hours on either side. Observing that the frequency and amount of precipitation (especially the frequency) grow less after the sun rises and do not increase materially until the sun starts downward, we remember that as the temperature rises in the forenoon the capacity of the air for moisture is greatly increased and the chances for condensation lessened; but, the warm part of the day is the time of greatest convectional activity and the time of greatest evaporation and accumulation of actual moisture in the air, and when the sun loses his power in the afternoon and the temperature begins to fall, the conditions rapidly become favorable for condensation. This may partially explain the chief maximum period of precipitation for the day, which occurs about 4 p. m. At night the atmosphere is comparatively stable, the disturbing sun being absent; hence, there is comparatively light and infrequent precipitation.

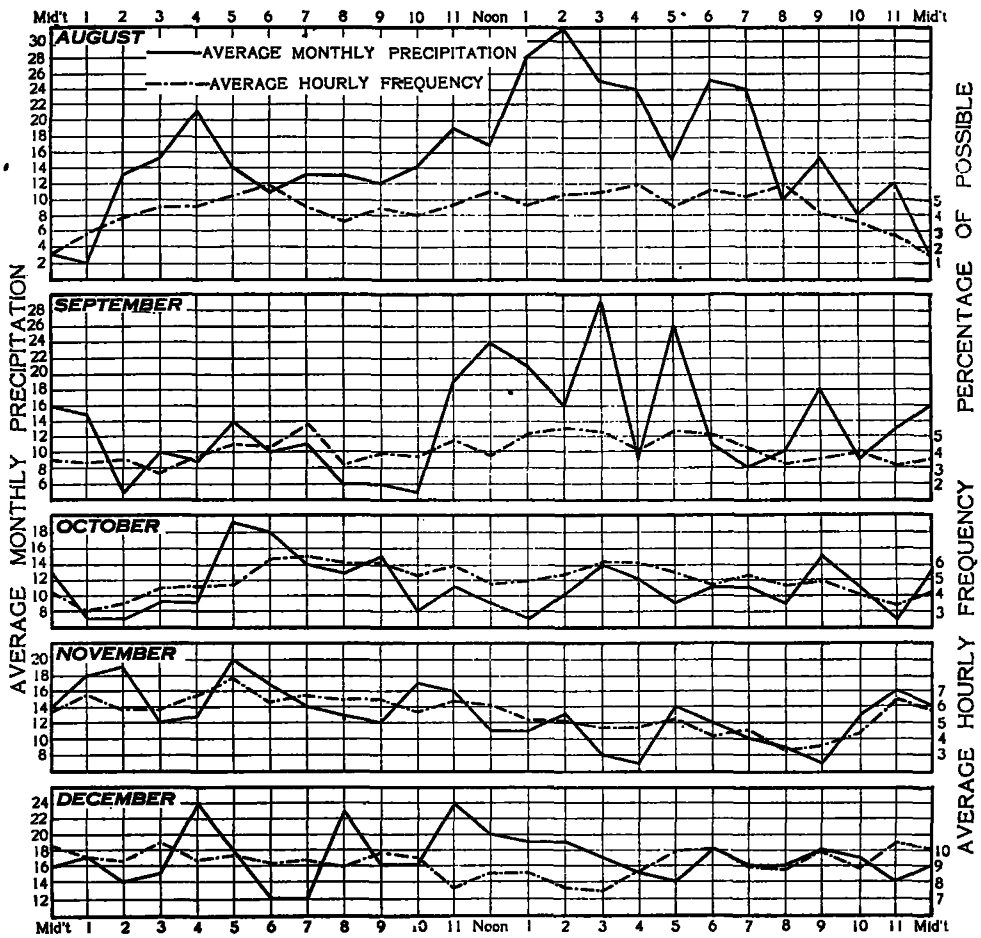

FIG. 16.—Average hourly precipitation (hundredths of an inch) and frequency, August to December, inclusive, for Nashville, Tenn.

It is interesting to note (but not unexpected) that the saying in Tennessee, "It never rains at night in July," is only partially borne out. The saying is scarcely more true of July than of June or August. Applied to the warm season as a whole, it has a basis of truth, for the most of the rainfall in summer, of course, comes in afternoon showers. As a matter of fact, the hour of least frequency of precipitation in the whole year is 11 p. m. to midnight in August, when the records show only 8 occurrences of a measurable amount in 17 years, or 1.5 per cent of the possible. However, to be exact, the average per cent of occurrence for the night hours, 8 p. m. to 4 a. m., is, in June, 7.75; July, 7; August, 7.50; while the average hourly amounts for those hours are, June, 0.12 inch; July, 0.07 inch; August, 0.11 inch. July night hours are thus shown to be, on an average, the driest hours of the year.

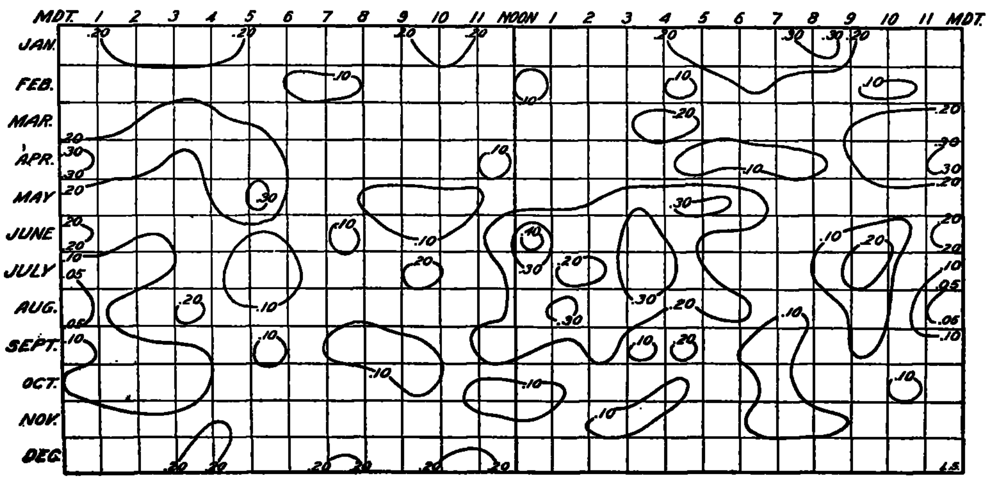

FIG. 2.—Average hourly precipitation for the year at Nashville, Tenn. (inches).

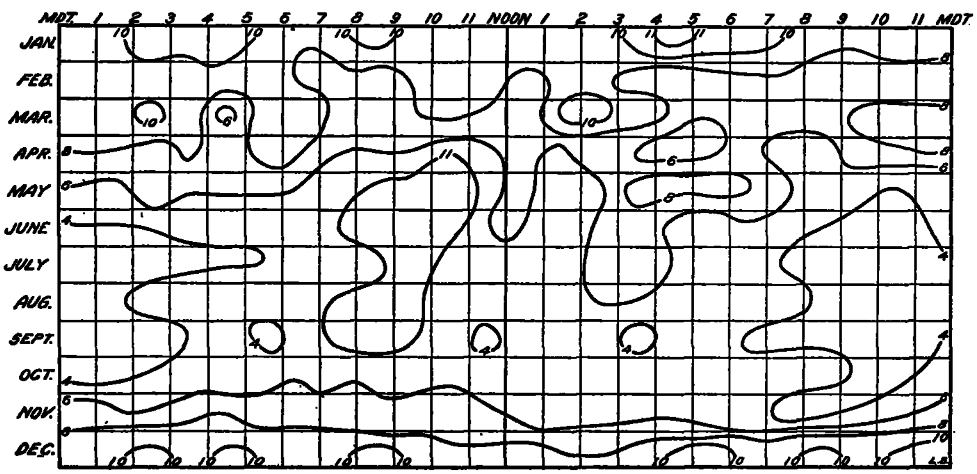

FIG. 3.—Average hourly frequency (percentage of possible) for the year at Nashville, Tenn.

TABLE 1.—*Average monthly precipitation, by hours, from records of 17 years, 1905–1921, at Nashville, Tenn.*

Months.	A. M.												P. M.												Sum.
	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11	Mid't.	
January	0.18	0.21	0.24	0.21	0.20	0.14	0.12	0.18	0.16	0.20	0.23	0.17	0.14	0.16	0.15	0.13	0.22	0.29	0.26	0.29	0.32	0.18	0.14	0.17	4.69
February	.16	.15	.15	.19	.15	.13	.12	.09	.07	.14	.11	.13	.09	.14	.14	.14	.10	.18	.20	.14	.15	.08	.10	.12	3.17
March	.17	.18	.29	.22	.20	.20	.16	.17	.15	.11	.13	.14	.15	.16	.17	.22	.23	.13	.15	.18	.18	.22	.25	.27	4.43
April	.38	.22	.21	.18	.27	.25	.16	.16	.13	.14	.15	.08	.15	.14	.17	.13	.10	.06	.10	.09	.10	.21	.22	.31	4.11
May	.13	.15	.15	.16	.28	.31	.16	.13	.08	.07	.05	.11	.12	.13	.21	.28	.31	.37	.26	.12	.18	.13	.19	.16	4.24
June	.21	.17	.10	.14	.12	.09	.13	.09	.13	.10	.12	.24	.44	.23	.23	.40	.21	.17	.19	.13	.08	.05	.05	.20	4.02
July	.05	.06	.06	.12	.08	.07	.08	.15	.12	.23	.19	.14	.26	.19	.20	.37	.33	.17	.10	.16	.06	.03	.14	.06	3.42
August	.02	.13	.15	.21	.14	.11	.13	.13	.12	.14	.19	.17	.28	.31	.25	.24	.15	.25	.24	.10	.15	.08	.12	.03	3.84
September	.15	.05	.10	.09	.14	.10	.11	.06	.06	.05	.19	.24	.21	.16	.29	.09	.26	.11	.08	.10	.18	.09	.13	.16	3.20
October	.07	.07	.09	.09	.19	.18	.14	.13	.15	.08	.11	.09	.07	.10	.14	.12	.09	.11	.11	.09	.15	.11	.07	.13	2.68
November	.18	.19	.12	.13	.20	.17	.14	.13	.12	.17	.16	.11	.11	.13	.08	.07	.14	.12	.10	.09	.07	.13	.16	.14	3.16
December	.17	.14	.15	.24	.18	.12	.12	.23	.16	.16	.24	.20	.19	.19	.17	.15	.14	.18	.16	.16	.18	.17	.14	.16	4.10
Sums	1.87	1.72	1.81	1.98	2.15	1.87	1.57	1.65	1.45	1.59	1.87	1.82	2.21	2.04	2.20	2.34	2.28	2.14	1.95	1.65	1.80	1.48	1.71	1.91	45.06
Means	.16	.14	.15	.16	.18	.16	.13	.14	.12	.13	.16	.15	.18	.17	.18	.20	.19	.18	.16	.14	.15	.12	.14	.16	3.75

TABLE 2.—*Average hourly frequency of precipitation at Nashville, Tenn. (percentage of possible), 1905–1921, inclusive.*

Months.	A. M.												P. M.												Sum.
	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11	Mid't.	
January	8.7	8.9	10.4	9.9	10.4	8.7	7.8	8.5	10.1	9.3	8.7	9.5	8.9	9.5	8.7	10.4	11.0	10.2	9.9	9.7	9.3	7.8	8.5	8.9	9.3
February	8.5	9.0	9.4	9.4	9.4	8.3	8.3	7.7	7.3	8.3	9.0	9.4	7.5	8.1	7.7	7.5	6.9	7.5	7.1	8.1	7.3	7.3	6.7	7.1	8.0
March	9.3	8.7	9.9	8.9	6.5	8.7	8.4	8.2	7.2	8.4	8.2	8.2	7.4	9.7	9.7	8.7	8.4	6.5	6.8	7.2	6.8	7.8	8.2	8.4	8.2
April	7.6	8.4	7.3	7.6	6.9	8.6	8.8	6.1	5.9	6.5	3.9	5.1	5.7	4.5	7.1	6.5	5.5	4.5	6.9	5.3	4.3	6.9	7.3	7.6	6.4
May	4.7	5.1	6.6	6.5	6.3	6.5	6.5	5.1	3.2	3.8	3.6	3.6	5.9	4.4	4.9	8.5	7.8	7.8	8.2	7.2	5.3	5.1	4.0	4.6	5.6
June	3.9	3.7	4.3	4.9	5.3	4.7	4.7	4.1	2.7	3.1	3.3	6.5	6.5	5.1	5.7	5.9	4.7	5.5	6.1	4.7	3.5	2.5	2.7	3.9	4.5
July	2.7	2.8	3.2	3.6	4.0	3.8	4.7	4.7	4.7	3.4	4.9	5.1	4.6	5.3	6.5	6.5	6.1	4.6	4.6	4.4	3.6	3.6	2.8	4.0	4.3
August	2.8	3.8	4.6	4.6	5.3	5.9	4.6	3.6	4.4	4.0	4.6	5.5	4.7	5.3	5.5	5.9	4.6	5.5	5.3	5.9	4.2	3.6	2.7	1.5	4.5
September	3.3	3.5	2.7	3.7	4.5	4.3	5.7	3.1	3.9	3.7	4.7	3.7	5.1	5.5	5.3	4.1	5.3	5.1	4.3	3.3	3.5	3.9	3.1	3.5	4.1
October	3.0	3.4	4.4	4.6	4.7	6.3	6.5	6.1	6.1	5.3	5.9	4.7	4.9	5.3	6.1	6.1	5.5	4.7	5.3	4.7	4.9	4.0	3.4	4.2	5.0
November	6.7	5.9	5.9	6.7	7.8	6.3	6.7	6.5	6.5	5.7	6.3	6.1	5.1	5.1	4.7	4.7	5.1	4.1	4.5	3.3	3.5	4.3	6.3	5.9	5.6
December	9.5	9.3	10.4	9.3	9.7	9.1	9.3	8.9	9.7	9.5	7.6	8.4	8.5	7.6	7.4	8.5	9.9	10.1	8.9	8.7	9.9	8.9	10.4	10.2	9.2
Sums	70.7	72.5	79.1	79.7	80.8	81.2	82.0	72.6	71.7	71.0	70.7	75.8	74.8	75.4	79.3	83.3	80.8	76.1	77.9	72.5	66.1	65.7	66.1	69.8	74.7
Means	5.9	6.0	6.6	6.6	6.7	6.8	6.8	6.0	6.0	5.9	5.9	6.3	6.2	6.3	6.6	6.9	6.7	6.3	6.5	6.0	5.5	5.5	5.5	5.8	6.2

TORNADOES OF APRIL, 1922.

DISCUSSION OF GENERAL CONDITIONS.

ALFRED J. HENRY.

[Weather Bureau, Washington, C. D., May 25, 1922.]

Three outbreaks of tornadoes occurred during the month, the first on the early morning of the 8th in north central Texas, extending in a northeast-southwest direction from Runnels County, Tex., into Comanche County, Okla., a distance of about 200 miles.

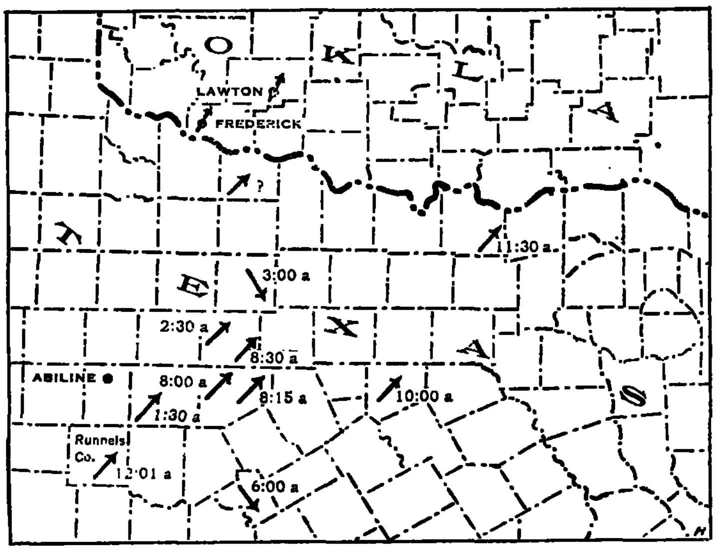

FIG. 1.—Region of tornado occurrence in Texas and Oklahoma, Apr. 8, 1922.

The exceptional character of this outbreak was the fact that practically all of the storms developed after midnight of the 7th. In the absence of detailed field data it is impossible to determine whether there was one general storm of long duration or a group of local manifestations of tornadic activity in the path of the main cyclone. The latter, after 24 hours' stagnation over Texas, moved rapidly during the 24 hours ending 8 a. m., 9th, to the upper Mississippi Valley, where it was centered as a circular storm of wide extent and low central pressure—29.00 inches. Another rather unusual circumstance in connection with this cyclonic storm was the fact that it was almost immediately followed by another, likewise of low barometer level at its center—viz. 29.30 inches at Dodge City, Kans., on the morning of the 10th.

This storm or cyclonic depression gave rise to the second outbreak of tornadic storms in southwestern Missouri, as described by Meteorologist W. B. Hare in the following pages.

The third and probably the most violent tornadoes of the month are described by Messrs. Root and Shipman. The pressure distribution in connection with these tornadoes was of the trough type with centers of minimum pressure in both the northern and the southern ends of the trough, respectively.

At 8 a. m. of the 17th there was a well-marked wind shift line separating the warm southerly winds on the east side of the axis of the trough from the relatively cooler north winds on the west side. In the succeeding 24 hours cool northerly winds swept over the region of warm southerly winds in which the tornadoes had their origin.

In all 42 persons were killed and 237 injured in these storms. The property loss was estimated as $968,150.

The foregoing does not include loss of life or property in Ohio, as reported by Meteorologist W. H. Alexander. See page 187.

IN TEXAS.

B. BUNNEMEYER, Meteorologist.

[Weather Bureau, Houston, Tex.]

Table 1 gives a summary of the tornadoes that occurred in Texas during April so far as reported to the section center. The property loss amounted to $232,150, and 14 persons were killed and 108 more or less seriously injured by these storms. All but one of the 11 tornadoes occurred on the 8th.

Special attention is invited to the hours of occurrence which varied between 12:01 a. m. and 11:30 a. m. The length of their paths could not be ascertained, but it is probable that in one or two instances the same tornado passed into an adjoining county. Figure 1 shows the approximate paths followed by the tornadoes. The hour of occurrence has been added to show possible connection between some of the tornadoes charted separately.

TABLE 1.—*Tornadoes in Texas during April, 1922.*

Locality.	County.	Date and hour of occurrence.	Direction of movement.	Width of paths (feet).	Property loss.	Number persons injured.	Number persons killed.
Goldthwaite	Mills	4th, 6.00 a. m.	nw. to se.	20	$8,150	0	0
Rowena	Runnels	8th, 12.01 a. m.	sw to ne.		55,000	52	7
Cisco	Eastland	8th, 8.00 a. m.	sw to ne.	33	25,000	3	0
Ranger	Eastland	8th, 8.15 a. m.	sw. to ne.	440	6,000	2	0
Oplin	Callahan	8th, 1.30 a. m.	sw. to ne.		15,000	30	5
Caddo	Stephens	8th, 8.30 a. m.	sw. to ne.	100	50,000	6	0
Breckenridge	Stephens	8th, 2.30 a. m.	sw. to ne.		2,000	2	0
Graham	Young	8th, 3.00 a. m.	nw. to se.	120	10,000	1	0
Cleburne	Johnson	8th, 10.00 a. m.	sw. to ne.	440	25,000	1	1
Electra	Wichita	8th,	sw. to ne.	100	25,000	10	1
Whitewright	Grayson	8th, 11.30 a. m.	sw. to ne.	500	11,000	1	0
Total					232,150	108	14